

2/8/15

-1-

- 1 "Rotor-grinding machine comprising a rotary head with two grinding wheels"

DESCRIPTION

- 5 The present invention is related to grinding machines for turbine or impeller blades or similar.

**Previous state of the technique**

- 10 The problem the present invention solves is the building of a grinding machine with a rotary head and two grinding wheels for grinding, controlling the grinding operations of the blade tips of a rotor, and the shape of the grinding wheel for grinding at the same time during  
15 the grinding cycle of a rotor period, by means of a control unit for the positioning of the grinding wheels and the shaping devices, and an optical sensor to measure the blade radius.

- 20 From publication US-A-5704826, a turbine rotor blade grinding machine is known where the head is foreseen of two grinding wheels with different features for grinding different rotors in view of the blade legation and width, which avoids the substitution of a grinding wheel and  
25 having to repeat the adjusting process of the angular and linear position of the head of the new grinding wheel respect to the new rotor, in the way it is necessary with the machines having a head with an only grinding wheel.  
30 In the grinding machine described in publication US-A-5704826, the angular and lineal displacements of the head to position the second grinding wheel are controlled by a control unit of the machine foreseen of a CNC, which calculates the coordinates of the new position starting  
35 from geometric data relative to the two grinding wheels,

BEST AVAILABLE COPY

1 with the cooperation of an optical measuring system to  
line up the grinding wheel and measure the radius of the  
blade tips.

5 An example of an optical system to line up the  
grinding wheel and measure the blade radius during the  
grinding operation at high speed of the rotor, controlled  
by means of stroboscope between 1500 r.p.m. and 3000  
r.p.m. is made to know in publication US-A-4566225, being  
10 the light intensity received at the sensor representative  
of the height or radius of the blades, but here the  
optical sensor uses an infrared light beam.

To obtain the wished shape bend at the blade tips,  
15 the grinding wheel carries out micrometric incremental  
displacements of the grinding wheel head in both  
directions, axial and radial, respect to the rotor during  
the grinding operation. The abrasion due to the use of  
the grinding wheel for grinding obliges to compensate for  
20 the wear and to correct the irregularities of its surface  
by means of a shaping device for the grinding wheel. The  
superficial irregularities of the grinding wheel provoke  
the appearance of burrs at the blade tips, which affect  
the radius measuring of the blades, and even originating  
25 an excess of grinding. A machine, known as the one  
disclosed in publication EP-0592112-A, has a shaping  
device foreseen of a diamond roller, supported on a  
carriage. This known machine has the inconveniences that  
the shaping device is separated from the grinding wheel  
30 head and situated behind it, and the shaping of the  
grinding wheel is executed once finished the grinding  
cycle of a rotor period, or also at the interval of a  
grinding cycle, stopping the grinding operation to  
separate the head from its working position and taking  
35 the grinding wheel till the roller. After the shaping,

1 the known machine has to place the grinding wheel well  
adjusted again, in touch with the blade tips to continue  
the grinding cycle.

**Exposition of the invention**

5

The object of the present invention is a grinding  
machine for compressor or turbine rotor blades, which  
includes a head with two different grinding wheels, whose  
positioning is directed by an electronic control unit of  
10 the machine, in cooperation with an optical system to  
measure the radius of the blades during the grinding  
operation, and a shaping device of the associated  
grinding wheel to the grinding wheel head, which can be  
activated automatically, in addition to previously fixed  
15 moments of the grinding cycle, during the grinding period  
in answer to an indication of the measuring signal  
generated by the optical system.

20 The electronic control unit, in addition to the  
angular and linear displacements of the grinding wheel  
head during the grinding, controls the positioning of one  
or the other grinding wheel on each rotor period, by  
means of the calculation based on the dimensions and  
25 geometric distances of both grinding wheels. The optical  
system to measure the blade radius is able to detect in a  
continuous way the presence of burrs on the blade tips,  
and the control unit activates the shaping device of the  
grinding wheel automatically during the grinding cycle,  
30 without altering the position of the grinding wheel and  
its rotation, and without it being necessary for an  
operator to be present. The shaping device is moved  
putting the shaping roller in touch with the grinding  
wheel. This way the grinding cycle is not interrupted,  
35 stopping only the forward movement of the grinding wheel.

**1 Description of the drawings**

Figure 1 is a top view of a grinding machine for a compressor rotor, showing the grinding of a rotor period.

**5** Figure 2 is a raised view of the grinding machine of figure 1.

**Detailed description of the preferred realization**

**10** With reference to figures 1 - 2, a preferred realization of a grinding machine 1 for the blades for a turbine or a compressor rotor 2 according to the invention includes:

- a machine bench 3,
- 15** - a carriage 4 supporting two pedestals 5 supporting the rotor 2 movable in an axial direction Z of the rotor 2,
- a grinding wheel head 6 foreseen of two grinding wheels for grinding 7, 7' with different features,
- 20** - a carriage 8 of the head to rotate the head 6 in an angular movement B around a central vertical shaft 6a, and two carriages 9, 10 of the head to move it in a linear movement to position it in the mentioned direction Z and a forward displacement of the grinding wheel in a
- 25** radial direction X of the rotor 2,
- a respective shaping device 12, 13 for each grinding wheel 7, 7' supported on an individual carriage 14, 15 associated to the grinding wheel head,
- an electronic control unit 16 including a numerical
- 30** control CNC to calculate and control the movements of the mentioned carriage, and
- a system 16 - 24 to measure the radius R of the blades, including an optical sensor 19 lined up according to the shaft with reference 11 (figure 1) with the rotor period
- 35** 2a of the grinding wheel 7 which is working, and a

1 measuring instrument, such as a PC computer, which  
transmits a signal 21, representative of the lining up of  
the grinding wheel 7 or of the grinding wheel 7' and of  
the measure obtained of the radius R to the control unit  
16.

5

The carriage 8 of the head gives the head 6 a  
rotation up to 180 around a central vertical shaft 6a,  
for the commutation of a grinding wheel 7 (figures 1 and  
2) to a second grinding wheel 7' selected for the  
10 grinding of a second rotor 2, different from the  
previously rectified one. An angular displacement B of  
the carriage is carried out for its relative inclination  
to the radius R of the blades, depending of the shape  
bend of the blade tips 25 that are being rectified. For  
15 the positioning of the mentioned second grinding wheel 7'  
faced in touch with the blade tips 25 of a second rotor  
2, the carriage 9, 10 offer the head 6 the linear  
displacements in the directions Z and X, apart from the  
incremental movement and forward "W" displacements of the  
20 grinding wheel during the grinding. The calculation of  
the position of the second grinding wheel 7' is carried  
out by the numerical control CNC in function of the  
diameters D1 and D2 of the two grinding wheels 7, 7' and  
25 of the diagonal distance 30 between the surfaces of both  
grinding wheels 7, 7' (figure 1).

The shaping device 12 - 15 includes a respective  
carriage 14, 15 supporting a diamond roller 12, 13, the  
30 carriage 14, 15 are incorporated on to the grinding wheel  
head 6 to accompany a respective grinding wheel 7, 7' in  
its linear displacements X, Z and angular displacement B.  
The carriage 14, 15 are projected above the head 6, and  
are moved vertically with its roller 12, 13 for the  
35 shaping of its corresponding grinding wheel 7, 7'

1 carrying out respectively a linear approaching  
displacement "U" or "C" from a retracted position above  
the grinding wheel 7 and forward movement of the roller  
12, 13 during the shaping. The carriage 14, 15 are  
foreseen of a screw 14', 15' for its linear displacement  
5 governed by the control unit 16, carrying out the shaping  
without the grinding wheel 7, 7' having to be withdrawn  
from its contact position with the rotor period 2a that  
is being rectified.

10 In a realization example of the grinding machine 1,  
the optical sensor 19 includes a light source 26 which  
issues a colimated beam 28 and an electronic  
photo-detector 27, situated on both opposed arms 19a, 19b  
15 of a support in the shape of an arch (figure 2) with  
greater dimension than the circle of the rotor periods  
2a. The opposed arms 19a, 19b of the sensor are situated  
including the rotor period 2a that is being rectified.  
Therefore the optical sensor 19 is supported on a  
20 carriage 18, which can be moved in the axial direction  
"Z" to move the sensor 19 from one rotor period 2a to  
another, and in a direction "Y" to carry out a radial  
forward movement towards the rotor blades 2a. The  
colimated beam 28 completely illuminates the blades which  
25 during their rotation pass between the source 26 and the  
photo-detector 27 receiving the latter an image of  
successive light and dark points corresponding to the  
light intensity corresponding to the crossing of each  
blade 25 with the beam 28. The PC computer receives an  
30 undulating electric signal 21 (not represented on the  
drawings) in each revolution, which is representative for  
the absolute value of the radius R. The signal 21 is not  
affected by the height of the blades interposed at the  
beam 28. The PC computer acquires and processes the  
35 signal 21 and combines it with a signal 24 of the

1 rotation speed of the rotor 2 proceeding from an  
"encoder" 17 of the rotor shaft, and the resulting signal  
22 is connected to a control unit 16, to control the  
grinding and the shaping. The alterations with respect to  
the values of the undulating signal 21 provoked by the  
5 burrs on the blades are detected by the control unit 16  
at each moment of the grinding cycle, actuating the  
device 12 - 15 of the corresponding shaping  
automatically.

10

15

20

25

30

35